The ROYAL COLLEGE of OPHTHALMOLOGISTS

focus

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Management of presbyopia

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What is presbyopia?

The eye's ability to focus on near objects, (accommodation), declines with age, from approximately 15 dioptres at the age of ten to 1 dioptre at sixty. Presbyopia occurs when accommodation becomes insufficient to carry out near vision tasks while fully corrected for distance. Studies provide evidence that presbyopia is caused by increased lens mass, resulting in greater thickness and an anterior shift of the lens. The rigidity of the lens prevents it from being deformed by the ciliary muscle reducing its focusing power. Age is the primary risk factor, but other factors can lead to premature presbyopia (see table).

Risk factor for premature presbyopia	Examples
Ethnicity	South Asian (specifically Indians and Malays) and African Caribbean
Refractive error	Hyperopia requiring additional accommodative demand if uncorrected
Ocular disease or trauma	Dry eye disease, ocular trauma, or any condition that causes damage to lens, zonules or ciliary muscle
Systemic disease	Acute coronary syndrome, anaemia, diabetes mellitus (especially high glycaemic level), influenza, measles, multiple sclerosis, myasthenia gravis, vascular insufficiency
Drugs	Alcohol, antidepressants, antihistamines, antipsychotics, antispasmodics, anxiolytics, chlorpromazine, diuretics, hydrochlorothiazide
Iatrogenic	Pan-retinal photocoagulation, intraocular surgery
Other	Cigarette smoking, decompression sickness, poor nutrition

Globally, presbyopia is the most common cause of visual impairment, affecting an estimated 1.8 billion people (Fricke et al., 2018). By 2050, it is expected to impact almost half of the aging population. Approximately 510 million people suffer from visual impairment due to lack of presbyopia correction, with higher prevalence in developing countries and rural areas (Bourne et al., 2021). Untreated presbyopia negatively affects quality of life and has significant economic consequences, coinciding with the peak of people's careers. Around 80% of individuals over 55 experience some degree of presbyopia. Undiagnosed presbyopia in individuals under 65 costs the global economy US$25 billion (Berdahl et al., 2020). Addressing presbyopia is an important unmet need and societal issue.

Treatment for presbyopia

Approaches to presbyopia treatment include:

- Reading "add" - additional positive power for near focusing
- Monovision – one eye adjusted for distance vision, the other for near
- Mini-monovision – a smaller interocular dioptric power difference between the eyes than monovision. However, it provides a narrower range of focus typically yielding distance and intermediate vision at a distance of approximately one metre.
- Multifocality - Usually bifocal or trifocal to give near and distance vision (plus intermediate in the case of trifocal)
- Enhanced depth-of-focus (EDOF) – creates a single elongated focus
- Reduced aperture optics – increases depth-of-focus through the pinhole effect
- Re-establishing accommodation

Non-invasive options

Optical aids

Spectacles and contact lenses are commonly used for treating presbyopia due to their familiarity, safety, and non-invasive nature. However, there is little literature regarding their efficacy and satisfaction. These aids can be monofocal, multifocal, or varifocal.

Many emmetropic patients or those with mild ametropia may choose to have reading spectacles for near vision. Progressive addition lenses (PALs) provide clear vision for a range of distances by creating a gradient of dioptre power that corrects for near and distance vision within the same lens. Despite several studies showing that PALs are preferred over bifocal/trifocal lenses, they cause peripheral aberrations that some patients find hard to tolerate (Katz et al., 2021).

Contact lenses offer options for monovision, mini-monovision, and multifocality, with comparable outcomes to PALs. However, they carry a small risk of infectious keratitis. Investigations into EDOF and pinhole contact lenses have also demonstrated positive results, but these approaches may be contraindicated in extremes of refractive error or ocular surface diseases (e.g., dry eye, corneal dystrophy).

Pharmaceutical treatment

Translational and clinical trials are exploring topical medications to treat presbyopia, focusing on miotics and lens softeners. Miotics extend depth-of-focus without compromising peripheral vision, while lens softeners aim to revive the crystalline lens's accommodative ability by breaking chemical bonds that cause stiffness. Miotic agents provide temporary improvement for up to 8 hours, with side effects (such as headache, dizziness, poor light perception, dry eye) that diminish over time. As for lens-softening medications, contrary to early clinical trials, larger trials did not show a statistically significant improvement in distance corrected near visual acuity (DCNVA) sustained beyond a few months (Mercer et al., 2021).

Surgical management

For individuals with presbyopia who cannot (physically or psychologically) or prefer not to use spectacles or contact lenses, there are surgical options available. It is important to consider the benefits against potential complications such as over- or under-correction, induced astigmatism, regression, delayed healing, epithelial in-growth, stromal haze, diplopia, ocular tenderness, infection, and rare cases of sight loss. Prior to undergoing irreversible surgical treatment, a trial using spectacles or contact lenses that mimic the desired post-operative effect may be recommended, except in cases where cataracts are present.

Keratorefractive surgery

Patients selected for corneal procedures usually do not have significant cataracts. Photorefractive keratectomy (PRK), laser-assisted in-situ keratomileusis (LASIK) and laser assisted lenticule extraction (LALEX, known under specific brand names such as SMILE) are three laser-based methods used to create monovision. Depending on preoperative refractive error, corneal thickness, presence of dry eye, occupation risk and time available for recovery, different options will be appropriate.

PresbyLASIK produces a multifocal ablation profile and attempts to preserve depth perception through one of three techniques: central presbyLASIK, peripheral presbyLASIK and laser blended vision (LBV). Central presbyLASIK creates a bifocal cornea with the central zone shaped for near vision and peripheral zone for distant vision, and vice versa in peripheral presbyLASIK. An EDOF effect is achieved with LBV by modulating either spherical aberration or asphericity.

Lens replacement surgery

An intraocular lens (IOL) is often implanted following cataract surgery, replacing the crystalline lens. Refractive lens exchange, also referred to as clear lens extraction, can also be performed in the absence of cataract. Different types of IOL include: monofocal, multifocal, and EDOF.

Multifocal IOLs can be subdivided into diffractive and refractive types. Compared to bifocal and trifocal diffractive lenses, refractive IOLs provide better intermediate vision with multiple zones of varying power and asphericity. However, because of the zonal design, its effect is limited by pupil diameter, and it can cause dysphotopsia. Apart from providing extended focus, EDOF IOLs have been shown to achieve better contrast sensitivity and less optical aberration compared with multifocal IOLs. However, patients will not have enough optical power for sustained near activity and may experience a phenomenon described as "starbursts". Difficulty in directly assessing the large number of IOLs on the market means that the decision is usually between monofocal, multifocal and EDOF lenses. Meanwhile, different lenses can be placed in the dominant and non-dominant eye in a "mix-and-match" approach to achieve better visual outcomes and compensate for different side effect profiles. Small aperture IOL has the same underlying mechanism as the corneal inlay but without their associated issue.

Accommodating IOLs are designed to react to ciliary muscle contraction and change curvature and/or position in order to provide accommodation with the majority working through the lens-shift principle. Research has shown that there is insufficient movement of the lens to be useful and the only Food and Drug Administration (FDA) approved accommodating lens showed posterior movement rather than anterior. They have also been shown to be more prone to capsular fibrosis post-implantation (Sheppard et al., 2010). IOLs made from deformable materials e.g., hydrogel, have been proposed. Various mechanisms are employed to change the lens shape such as thermoelectric, electrohydrodynamic and magnetic, although most have only been characterised in vitro. We are still some distance away from mimicking dynamic accommodation with fast and accurate changes in lens curvature and position.

For all invasive approaches, there is a compromise in performance accepted to different degrees by individuals, including blurred distance vision, dysphotopsia, reduced contrast sensitivity, loss of depth perception, and poor night vision. There is also a risk of complex optics becoming less usable in the event of glaucoma, macular ageing, and cognitive decline.

Summary

Presbyopia has a significant physical, psychological, and economic impact, particularly in developing countries. Spectacle correction is the most obvious option in these areas because they generally have limited surgical infrastructure. There is no perfect solution for restoring accommodation, but recent developments offer personalised treatment options. Nonetheless, continued research is necessary to assess the performance, predictability, efficacy, and safety of novel approaches. Ultimately, successful treatment outcomes depend on careful patient selection, comprehensive education, and close follow-up.

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